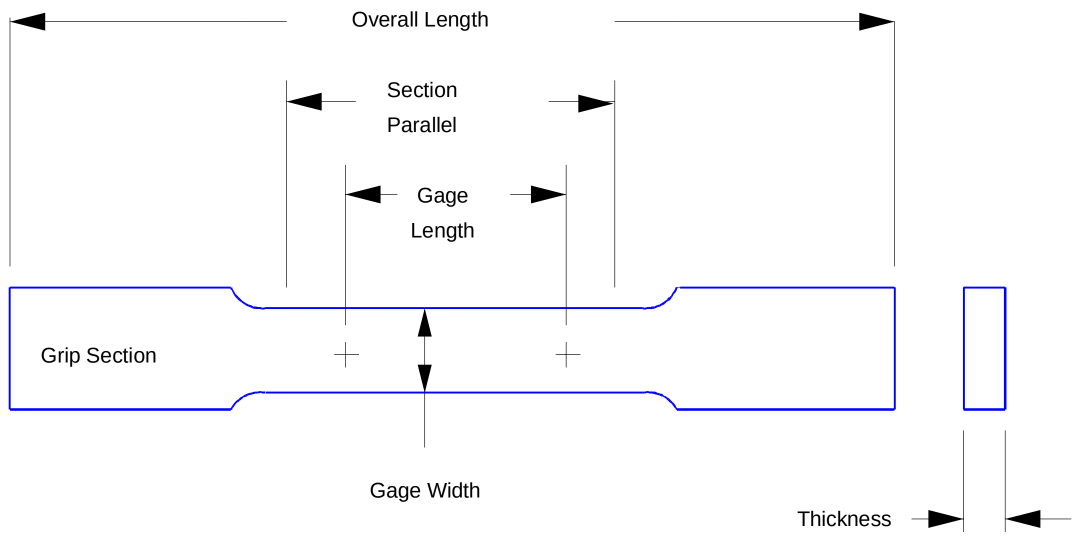
2.12 MECHANICAL TESTING

2.12.1 INTRODUCTION

Mechanical properties are specified for certain automotive applications. The more common properties are those obtained in a tension test or hardness test made on a representative sample of the sheet steel. The standard sheet specimen used in the tension test is shown in Figure 2.12-1.



Rectangular Tension Test Specimen for Sheet (1/2 Inch Wide Test)

Dimension	inch	mm
Overall Length	8	200
Gage Length	2.000 ± 0.005	50 ± 0.10
Gage Width	0.500 ± 0.010	12.5 ± 0.25
Thickness	Thickness of Material	

Figure 2.12-1 Standard sheet tension test specimen

ASTM A370 describes the standard tension test. In this test, an increasing axial load is continuously applied by a tension testing machine to the specimen until the specimen fractures. During the test the elongation of the gage length on the specimen is continually measured. The relationship between the applied load and corresponding elongation is plotted as a load versus elongation diagram. The applied load divided by the original cross sectional area of the specimen is the engineering stress. The change in length of the gage length divided by the original gage length, expressed as a percent, is the engineering strain or percent elongation.

Stress strain curves generated from the standard tension test are illustrated in **Figure 2.12-2** below. Yield strength may be depicted and described in two ways, depending on the stress-strain characteristics of the steel as it begins to yield:

a. The minimum stress in the yield point elongation region (YPE) for materials exhibiting discontinuous yielding.
b. The stress at 0.2 percent strain offset, for materials exhibiting a continuous yielding stress strain curve.

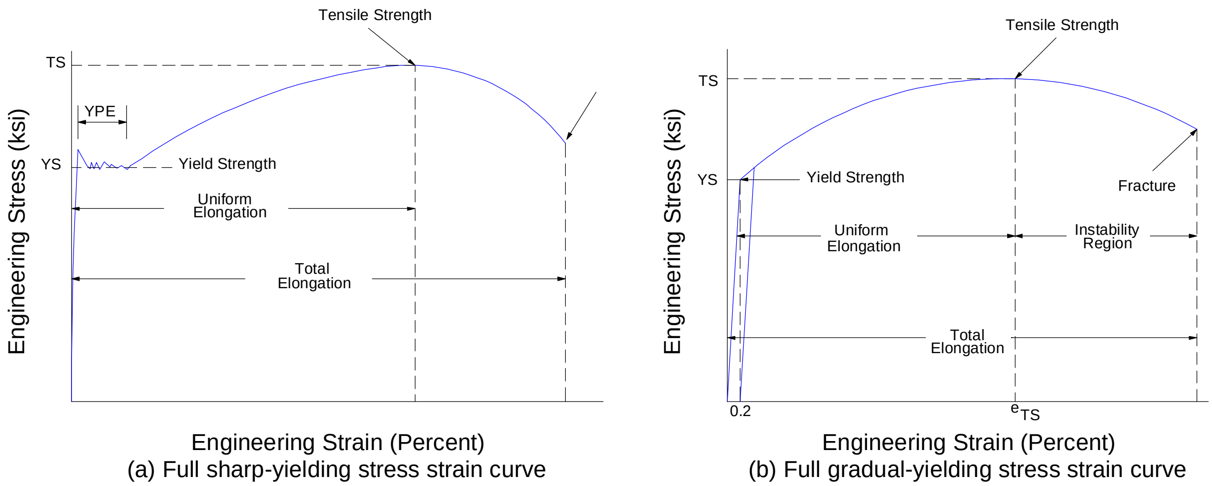


Figure 2.12-2 Complete stress-strain curves showing continuous and discontinuous yielding.

2.12.2 METALLURGICAL TERMS

Modulus Of Elasticity

The modulus of elasticity is the slope of the stress versus strain diagram in the initial linear elastic portion of the diagram . It is a measure of the stiffness of the metal. The value for steel is approximately 200,000 MPa (29,500 ksi). The value does not change appreciably with changes in composition, steel manufacturing processes, or fabrication operations.

Yield Strength

The stress at which the metal yields or becomes permanently deformed is an important design parameter. This stress is the elastic limit below which no permanent shape changes will occur. The elastic limit is approximated by the yield strength of the material, and the strain that occurs before the elastic limit is reached is called the elastic strain. The yield strength is defined in three ways, depending on the stress-strain characteristics of the steel as it begins to yield. The procedures in SAE J416, ASTM E8, and ASTM A370 describe the testing for tensile properties. Stress-strain curves showing continuous and discontinuous yielding are shown in Figure 2.12-2.

Tensile Strength

Tensile strength is the maximum load sustained by the specimen in the tension test, divided by the original cross sectional area. The tension test described in ASTM A370 is explained in an earlier portion of this report. Also see Figure 2.12-2.

Uniform Elongation
The strain to maximum load in the tension test is called the uniform elongation. It is the limit of plastic strain that is uniformly distributed over the strained area. Following the uniform elongation, deformation is concentrated in one region of the specimen, creating a localized reduction in cross section referred to as necking.

Hardness
Hardness is the resistance of metal to indentation. There is no absolute scale for hardness. Each of the different hardness tests has its own scale of arbitrarily defined hardness. The most common test used to measure the hardness of steel sheet is the Rockwell hardness test. The Rockwell hardness number is derived from the net increase in depth of impression as the load on an indenter is increased from a fixed initial load and then returned to the initial load.

Elongation
The Elongation is a direct measure of ductility and represents an important consideration in evaluating formability. Elongation is usually reported as a percent increase in length within the 50 mm gage length of the tension test specimen.

Work Hardening Exponent, n value
The work hardening exponent, **n**, is related to the steepness of the stress-strain curve in the plastic deformation region; it also correlates with the uniform elongation of the steel and the ratio of the tensile strength to yield strength. Determination of the **n** value from load elongation curves is described in ASTM E 646. Most important, the strain hardening exponent correlates to the ability of the metal to be stretch formed. A higher **n** value indicates a capability for the metal to strain harden in areas that have been cold worked by deformation processes. This capacity to transfer strain contributes to a better response to biaxial stretch deformation modes.

Plastic Strain Ratio, r Value
The plastic strain ratio **r** is a measure of the resistance to thinning as metal is drawn, controlled by the crystallographic orientation of its structure, which is dependent on the chemical composition and processing of the material. The procedure for measuring **r** value can be found in ASTM E517. For anisotropic materials, the **r** value changes with test direction, and for convenience is measured in directions longitudinal (0 deg.), diagonal (45 deg.), and transverse (90 deg). Higher **r** values indicate a greater resistance to thinning, and are directly related to an increased ability of the sheet to be formed by deep drawing.